SENSORY FEEDBACK SYSTEM FOR PROSTHETIC HAND BY USING INTERFERENTIAL CURRENT

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Abstract - The purpose of this study was to develop a new type of sensory feedback system for myoelectrically controlled biomimetic prosthetic hand. One of the characteristic features of the neuromuscular control system in man is the increase in the compliance around the joint with decreasing activity of the muscle. We used interferential current that uses two waves and interfere to synthesize a low frequency in the body. One frequency was fixed at 4000 Hz and the other frequency was changed from 3700 Hz to 4000 Hz. As the result stimulus frequency in the body was changed from 0 Hz to 300 Hz. By the experiments, we measured that the subjects could distinguish the change of stimulus frequency and confirmed that the interference current is useful method for sensibility feedback device of a prosthetic hand. As a future task, we will try to produce a sensibility feedback device for a prosthetic hand, using the interference current

***Keywords* - sensory feedback system, prosthetic hand, interferential current**

I. INTRODUCTION

A powered prosthetic hand is used to replace the functions of a natural hand lost by an accident or a disease. In developing a prosthetic hand, three points are important. First point is that its shape should be like that of the human hand. Second point is that an amputee must be able to voluntarily control the opening and closing of the hand. The last point is the hand has ability to transmit the status of the hand to the amputee. In order to satisfy these demands, many kinds of powered prosthetic hands, controlled by electromyogram (EMG) signals, have been developed. Such myoelectric hands are controlled in the ON-OFF mode or in simple proportional mode, according to the amplitude of EMG signals. Although much progress has been made, the motor functions of such myoelectric hands are still not comparable with those of a natural hand, partly because they are designed with little consideration of the natural control mechanisms in the human hand.

In this study we direct our attention to the sensory feedback system. If a prosthetic hand has the same mechanisms and mechanical properties as the neuromuscular control system of the human hand, an amputee may be able to utilize almost the same subconscious control as used before amputation of the hand when controlling the prosthetic hand. Consequently, training periods required for the amputee to operate such a prosthetic hand would be much shorter than that for a conventional myoelectric hand. If the prosthetic hand has ability to transmit the status of the hand, such as finger angle or grasping force, to the amputee, the amputee will be able to execute fine tasks or handle breakable objects more easily with this hand than with conventional myoelectric prosthetic hands.

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The purpose of this study is to develop a sensory feed back system for myoelectric prosthetic hand. This system transmit the state of the myoelectric hand, such as grasping force, finger angle or slipping information to the objects.

II. STIMULATING METHOD

It becomes a very important that a control system of the prosthetic hand is its own support type and its own built-in type when we consider a sensory feedback system for a prosthetic hand. From this point of view, an electric stimulation is an expectation in contrast to mechanical stimulation, because it is possible to make the system small and its energy consumption is low. On the other hand, skin impedance, pain and interference to the myoelectric control system when the electric stimulation applies near an electrode for electromyogram become problems.

Interferential current (IFC) method settles problems of skin impedance and pain, because an electric power of IFC stimulates internal organization through a skin. IFC makes two waves interfere to synthesize a low frequency in the body.

Normally the electric stimulation uses the frequency from a 2 or 3 Hz to about 200 Hz. But the skin impedance for this frequency range is high. Therefore we use the rather high frequency signal. The typical IFC stimulator utilizes two sinusoidal AC output circuits that differ somewhat in frequency. When these two outputs intersect, the frequency difference causes the sine waves' amplitudes to summate, resulting in the so-called “beat” or “envelope” (Fig. 1). From an electrophysiological perspective, each “beat” represents a polyphasic pulse of varying amplitude, from which the term amplitude-modulated AC was derived.

Merits of IFC are the followings.

1) Electric current occurs in the body and is safe.
2) We can choose a stimulating point by arranging position of electrodes and changing size.
3) Skin impedance is low, because the frequency of the current going through the skin is high.

In this study, it is investigated whether such an interference wave is valid as sensibility feedback equipment for the prosthetic hand use or not.

III. METHOD

Four stainless steel electrodes were fixed on the forearm with electrode paste. Before the fixing the electrode, the skin was whipped with alcohol. In the experiment, we fixed the channel-1 frequency for 4000 Hz and changed the channnel-2 frequency as follows. 1) We measured how an interference wave was felt when the both frequencies were same 4000 Hz. 2) We measured the frequency that the subject felt the change each time when the channel-2 frequency gradually decreased

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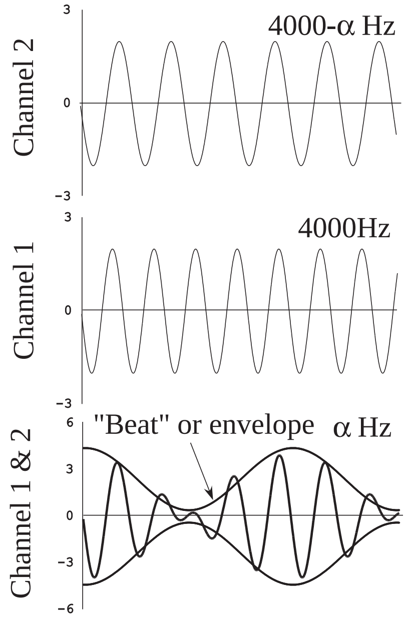

Fig. 1 Generation of interferential current

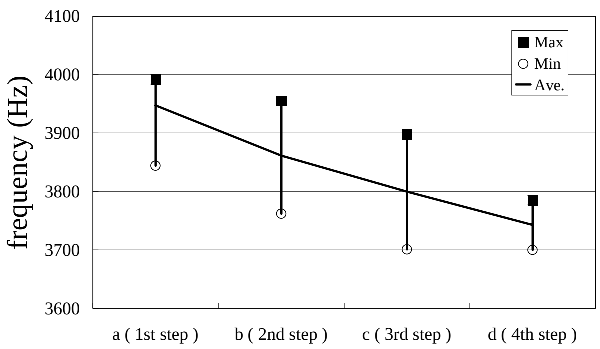

Fig. 2 Frequency decrease mode

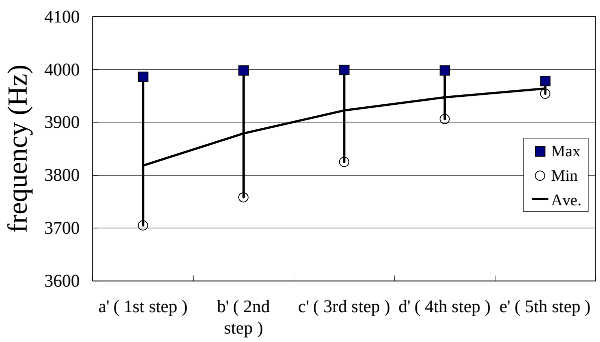

Fig. 3 Frequency increase mode

from 3999 Hz to 3700Hz and denoted the frequency as a, b, c, d, and e.

3) We measured the frequency that the subject felt the change each time when the channel-2 frequency gradually increased from 3700 Hz to 3999 Hz and denoted the frequency as a', b', c', d' and e'.

Each experiment repeated 10 times for each subject. The subjects are eight healthy young volunteers.

IV. Results

In case that the frequency of channet-2 is the same as that of channnel-1, all subjects felt nothing. Fig.2 shows the maximum, minimum and average frequency that the subject felt difference of stimulation, when the frequency of channel-2 decreased from 3999 Hz to 3700. One subject could distinguish maximally five steps. Fig.3 shows the results when the frequency of channel-2 increased from 3700 Hz to 3999. One subject could distinguish maximally six steps. Fig.4 and 5 show the number of steps that the subjects could distinguish the difference.

V. Discussion

The number of steps which the subjects can feel difference of stimulation frequency when the stimulation frequency was decreased gradually was larger than that when the stimulation frequency was increased. This result shows that the subject can feel the frequency change precisely in case of frequency decrease. For the use of the sensory feedback system of the prosthetic hand, much more information will need when the prosthetic hand will grasp the object in compare with releasing the object. Therefore, the change of channnel-2 frequency should be decrease when the prosthetic hand grasps the object and be increase when the prosthetic hand releases the object.

VI. Conclusion

By this study, we confirmed that the interference current is useful method for sensibility feedback device of a prosthetic hand. As a future task, we will try to produce a sensibility feedback device for a prosthetic hand, using the interference current.

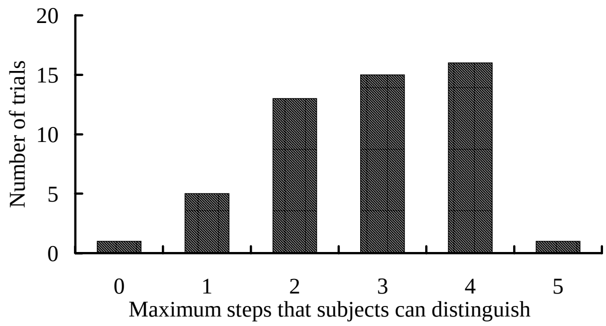

Fig. 4 Number of steps distinguished in frequency decrease mode

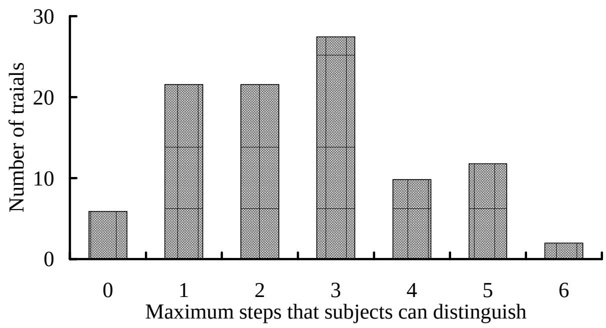

Fig. 5 Number of steps distinguished in frequency increase mode